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(71) Applicant: THE CENTER FOR BLOOD RESEARCH [US/US]; 800 Huntington Avenue, Boston, MA 02110 (US).

(72) Inventor: REMOLD-O'DONNELL, Eileen ; 197 Clinton Road, Brookline, MA 02146 (US).

(74) Agent: GATES, Edward, R.; Wolf, Greenfield & Sacks, 600 Atlantic Avenue, Boston, MA 02210 (US).

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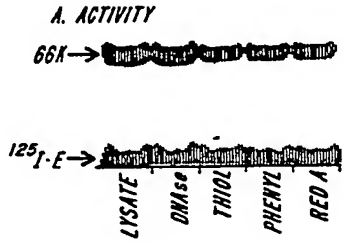
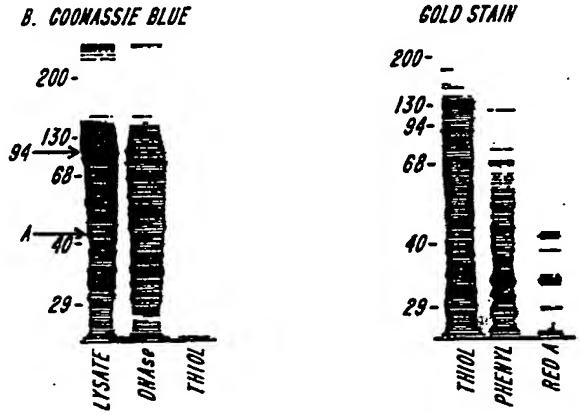
(54) Title: HUMAN ELASTASE INHIBITOR

(57) Abstract

A new human elastase inhibitor is provided. The human elastase inhibitor is isolated, purified, characterized at the molecular level and cloned. The human elastase inhibitor is substantially non-glycosylated, is capable of forming a covalent complex with elastase and is capable of inhibiting elastase.





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HUMAN ELASTASE INHIBITOR

This invention relates in general to molecular biology, pharmacology and medicine and in particular to the isolation, purification and cloning of a human proteinase inhibitor.

Preservation of the integrity of local organ function requires a delicate balance of the activities of phagocytic cell proteinases and the action of proteinase inhibitors. Loss of this balance is believed to be a major causative factor in the pathogenesis of asthma, chronic bronchitis, emphysema, sarcoidosis, respiratory distress syndromes, arthritis, and certain skin diseases and possibly malignancies. For example, excess release of elastase by neutrophils and monocytes as well as excess accumulation of monocytes and neutrophils are believed responsible for tissue injury in inflammatory conditions such as arthritis and emphysema and in neutrophil mediated injury to endothelial cells. To acquire the ability to monitor and manipulate the proteinase-proteinase inhibitor balance requires that the relevant molecules be identified, isolated and purified.

Of the phagocytic cell proteinases, an important one is the serine active site proteinase that is commonly called "neutrophil elastase". Human neutrophil elastase is a 218 amino acid glycosylated

protein of known sequence that is particularly abundant in neutrophils (0.5% of total protein) and is also found in monocytes and macrophages. Elastase cleaves extracellular matrix proteins such as elastin, proteoglycans, fibronectin, type III and type IV collagen, and certain soluble proteins. It also is required by neutrophils for their migration through cell barriers in vitro.

The continuous action of elastase inhibitors in vivo is evident from the neutrophil turnover rate. Despite the fact that neutrophils enter most body sites, turnover of about 10^{11} neutrophils with a content of about 50 mg elastase occurs daily in humans without evidence of uncontrolled tissue degradation.

A prevalent soluble blood protein, α1-antitrypsin (α1-AT), is a fast-acting elastase inhibitor in vitro. Individuals with genetically reduced levels of α1-AT (homozygous Z-variant) are predisposed to develop pulmonary emphysema in the third or fourth decade of life due to uncontrolled elastase action. Human α1-AT currently is used to treat congenital α1-AT deficiency.

Molecules differing from α1-AT that fulfill the requirements of a physiological regulator of neutrophil elastase activity have been detected in monocytes and neutrophils in several species. It was

reported in 1971 that an endogenous elastase inhibitor with properties of a protein was detected in the cytosolic fraction of human blood leukocytes and human lung macrophages (1, 2). Cytosolic proteins that inhibit elastase were identified and purified from horse blood neutrophils (3, 4), pig blood leukocytes (5) and bovine lung macrophages (6). An elastase inhibitor in the extracellular fluid of cultured guinea pig macrophages has been identified by its ability to form a covalent complex with elastase (7). Larger quantities of the guinea pig elastase inhibitor have been found in macrophage lysates (7). More recently, a prevalent, fast-acting endogenous elastase inhibitor protein has been detected in mature human monocytes and monocyte-like cells (8). To date, no one has been able to isolate, purify, characterize and clone this human elastase inhibitor.

SUMMARY OF THE INVENTION

According to the invention, Human Elastase Inhibitor (Human EI) is isolated, purified, characterized at the molecular level and cloned. Human EI is substantially non-glycosylated, is capable of forming a covalent complex with elastase and is capable of inhibiting the elastinolytic activity of elastase. The molecule appears to have a

cysteine residue essential for interaction with elastase, since the treatment of Human EI with iodoacetamide is capable of preventing Human EI from forming a complex with elastase. Human EI is stable to reducing agents; purified Human EI appears to have a blocked amino-terminus. Human EI has a molecular weight of about 42,000.

Human EI has been partially sequenced and includes the following segments:

Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

In addition to purified or substantially purified Human EI, the invention also provides recombinant derived Human EI, and derivatives, variations, and portions of Human EI.

Preferably, a human cDNA library from monocytes or monocyte-like cells is expressed in suitable host cells using conventional expression vectors to yield colonies, each colony expressing a different portion of the cDNA library. Then, the colonies are screened using an oligonucleotide encoding at least a portion of one of the foregoing protein sequences to identify that colony containing the cDNA for Human EI or a functionally equivalent derivative or portion thereof.

The recombinant expression vector then may be isolated from the selected colony. The vector contains a DNA sequence encoding at least a portion of the Human EI molecule, and preferably, the vector is capable of effecting the expression of a DNA sequence encoding a molecule capable of acting as an inhibitor of a serine proteinase. In one embodiment the encoded molecule is capable of forming a covalent complex with elastase and/or capable of acting as an inhibitor of elastase.

The encoded molecule may be selected from the group consisting of:

(1) Human EI;

(2) variations, portions or derivatives of Human EI;

(3) a molecule including the protein sequence of Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

(4) a molecule including the protein sequence of Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

(5) a molecule including the protein sequence of Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

(6) a molecule including the protein sequence of Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

(7) a molecule including the protein sequence of Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

(8) a molecule including the protein sequence of Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

(9) a molecule including the protein sequence of Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

(10) a molecule including the protein sequence of Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

(11) a molecule including the protein sequence of Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

(12) a molecule including the protein sequence of Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

Substantially pure preparations of oligonucleotides encoding Human EI, or variations, derivatives or portions thereof also are provided. These oligonucleotides may be DNA, RNA, sense or antisense and may be natural, synthetic or recombinant. Likewise, preparation of antibodies

with selective specificity for or capable of binding with Human EI.

The Human EI, antibodies to EI Human and oligonucleotides and vectors encoding Human EI and variations, derivatives or portions thereof may be used alone or coupled with other moieties to treat various medical conditions and/or as diagnostic tools in determining the existence and degree of such conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an autoradiograph showing the presence of Human EI at certain steps during purification;

FIG. 2 is a graph showing dose-dependent inhibition of elastinolysis caused by Human EI;

FIG. 3 is an autoradiograph showing Human EI and Human EI complexed with elastase;

FIG. 4 shows the amino acid composition of pure EI as compared to that of α1-AT; and

FIG. 5 is an autoradiograph showing the presence of Human EI in monocytes, neutrophils and U937 cells.

DETAILED DESCRIPTION OF THE DRAWINGS

Human EI is a fast acting, cell-associated, essentially irreversible inhibitor of porcine pancreatic elastase and human neutrophil elastase, both serine active-site protein elastases

(hereinafter "elastase"). It is found at high levels in neutrophils, monocytes and macrophages. Human EI reacts quantitatively with elastase to form an EI-elastase complex and to inhibit the elastinolytic activity of elastase. The complex is stable in boiling SDS (sodium dodecyl sulfate), indicating a covalent bond between the EI and the elastase.

Based on functional criteria, Human EI may be grouped with the serine proteinase inhibitors of the Serpin family. Human EI does not react with elastase that has been inactivated with the serine active site reagent DFP (diisopropyl fluorophosphate). The covalent complex is stable in boiling SDS and also is susceptible to base-catalyzed cleavage. These mechanisms of action are characteristic of serine proteinase inhibitors of the Serpin family. However, Human EI differs from other serine proteinase inhibitors in that the treatment of Human EI with iodoacetamide abrogates its ability to form a complex with elastase, indicating an essential cysteine residue.

Human EI is a single polypeptide having a molecular weight of about 42,000. Compositional analysis indicates that there are five cysteine residues per molecule of approximately 360 amino acid residues. The negligible levels of carbohydrate detected on gas-liquid chromatography and the insensitivity of Human EI to treatment with the

glycosidase PNGase F (peptide:N-glycosidase F) indicate that Human EI is non-glycosylated or substantially non-glycosylated (possibly one or two residues). The amino-terminus of purified Human EI appears to be blocked.

Pure Human EI was partially sequenced and includes the following sequences:

Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

Purification of Human EI

A series of steps were involved in the purification of Human EI. The presence of Human EI was confirmed at each step by the ability of a sample

taken at each step to form a covalent complex with ^{125}I-elastase. (7, 8) The details of the confirmation procedure are set forth in the foregoing references, the disclosures of which are incorporated herein. In general, fractions suspected of containing Human EI were incubated at 37°C for 10 minutes with 30-200 ng of ^{125}I-labeled porcine pancreatic elastase (Elastin Products, Pacific, MO.) The covalent EI-elastase complex was detected by autoradiography after SDS polyacrylamide slab gel-electrophoresis using the Fairbanks/Laemmli gel system. This system employs relatively low pH and low primary amine concentration to minimize hydrolysis of the complex during electrophoresis (8).

Obtaining Cell Lysates.

U937 cells were used as the source of Human EI. U937 cells are human histiocytic lymphoma cells (9). The particular U937 cells used are believed to be a subline at a slightly more advanced stage of differentiation than U937 as originally characterized (9). The cell line used is hereafter referred to as U937-EI. This cell line has been deposited at the ATCC, Rockville, Maryland, under Accession Number CRL 10026.

U937-EI cells were grown in RPMI 1640 medium or Dulbecco's modified Eagles medium with 4.5 mg/ml

glucose, 10% FCS and 50 micrograms per ml gentamycin. The U937-EI cells from 12 liter cultures (approximately 1.8 x 10^{10} cells) grown by the Massachusetts Institute of Technology Cell Culture Center were washed twice by pelleting at 4° C in Ca^{++}/Mg^{++} containing PBS. The cells at 2 x 10^7 per ml in HBSS (Hanks' Balanced Salt Solution) were incubated at about 22° C for 15 minutes to remove adsorbed α1-AT (8). The cells were brought to 4° and pelleted. Lysates (2.5 x 10^7 cells per ml) were prepared by extracting the cells with 0.5% NP-40 (Nonidet P-40 [NP-40] is a nonionic detergent marketed in the United States by Gallard Schlesinger, Carle Place, NY. The material is an octyl phenol ethylene oxide condensate with 9 moles ethylene oxide. It is a product of BDH Limited, Poole, England; BDH obtains the material from Shell Chemical Co., England) in PBS for 4 minutes at about 22° C and 10 minutes at 4° C, and clarified by centrifugation in a Sorvall SS34 rotor (Dupont Co., Wilmington, Delaware) at 18,000 rpm for 30 minutes at 4°C.

Separation of Actin on DNAse-Sepharose. In preliminary purification experiments, EI activity was lost concomittant with the formation of actin (10) containing precipitates. To avoid this loss, the cell lysates were immediately chromatographed on DNAse-Sepharose, which specifically absorbs actin.

The DNAse Sepharose affinity resin was prepared as follows: Deoxyribonuclease I (bovine pancreas; 1800 Kunitz units/mg protein; Sigma Chemical Co., St. Louis, MO) was treated with 2 mM diisopropyl-fluorophosphate (DFP) in PBS for 30 min at 22°C, and was coupled at 3 mg/ml in 0.1 M $NaHCO_3$, pH 8.5 to activated Sepharose by mixing for 18 hr at 4°C (greater than 90% coupling efficiency). The activated Sepharose was either Activated Sepharose 4B supplied as an activated lyophilized powder by Pharmacia Fine Chemical (now Pharmacia LKB Biotechnology, Inc., Piscataway, New Jersey), which was reconstituted and prepared for coupling following the manufacturer's suggestion (i.e., reconstituted with 1 mM HCl and washed with 1 mM HCl at 22°C for 15 min. followed by washing with coupling buffer) or Sepharose 6B activated immediately before coupling (P. Cuatrecasas, "Protein Purification by Affinity Chromatography: Derivatives of Agarose and Polyacrylamide Beads", J. Biol. Chem., 1970, 245: 3509-3065) by treatment with CNBr (2.3 g per 100 ml Sepharose) at pH 11 and ~22°C for 10 min. The resin was treated at 22°C once with 10 mM Tris-HCl buffer, pH 8.0 for 2 hr; three cycles with 100 mM sodium acetate buffer pH 4.0 followed by 100 mM $NaHCO_3$ pH 8.5; once with PBS; and once with 2 mM DFP in PBS for 30 min. The resin was stored in PBS with 0.02% sodium azide at 4°C and was equilibrated with PBS immediately before use.

The cell lysate (~720 ml) was incubated with 180 ml DNAse-Sepharose for 30 minutes at 4°C in a roller bottle. The mixture was transferred to a 6.5 cm diameter column, and the nonadherent fraction, together with a 0.8 column volume wash with 0.5% NP-40 in PBS was stored at -70°C. The presence of Human EI in the nonadherent fraction was measured as set forth above. As shown in FIG. 1, a protein in the nonadherent fraction combined with elastase to form the ^{125}I-elastase - elastase inhibitor complex of apparant molecular weight 66,000.

Thiopropyl-Sepharose-6B Separation. Thiopropyl-Sepharose 6B is a mixed disulfide affinity resin supplied by Pharmacia Fine Chemicals. It contains approximately 20 μ moles per ml swollen gel of 2-thiopyridyl residues in mixed disulfide linkage to hydroxpropyl residues; the latter residues are linked to the Sepharose 6B matrix via ether linkage. Thiopropyl-Sepharose 6B is synthesized by a method such as that described by R. Axen, Drevin, H. and Carlsson, J. (Preparation of modified agarose gels containing thiol groups, Acta Chem. Scand. B, 1975, 29, 471-474). Human EI adheres to Thiopropyl-Sepharose-6B, while most proteins do not. The Thiopropyl-Sepharose-6B was equilibrated against 0.5% NP-40, 10 mM Tris-HCl buffer, pH 7.4, 150 mM NaCl, 1 mM EDTA (NP-40/Tris/150-NaCl/EDTA) at 22°C

for 30 min. The DNAse-nonadherent fraction (~900 ml) then was incubated with occasional stirring at 22°C with 30 ml of the Thiopropyl-Sepharose-6B. The mixture was transferred to a 3 cm column and washed sequentially with one column volume of NP-40/Tris/150-NaCl/EDTA, NP-40/Tris/500-NaCl, Tris/500-NaCl, and Tris/150-NaCl. The column was eluted with 50 mM mercaptoethanol in Tris/150-NaCl to yield a single 70 ml "Thiol eluate" fraction. Again, the presence of Human EI was confirmed as set forth above. As shown in FIG. 1, a protein in the Thiol eluate fraction combined with elastase to form the ^{125}I-elastase - elastase inhibitor complex.

Phenyl-Sepharose-CL4B Separation. Sepharose is the registered trademark for spherical agarose gel beads manufactured by Pharmacia Fine Chemicals. Sepharose 6B, ~6% agarose, consists of 40-210 micron particles; Sepharose 4B, ~4% agarose, consists of ~40-190 micron particles. The agarose used to manufacture Sepharose is produced from selected agar (Hjerten, S., "A New Method for Preparation of Agarose for Gel Electropheresis". Biochim. Biophys. Acta 1962, 62: 445-449 and S. Hjerten, Chromatography on agarose spheres, in "Methods in Immunology and Immunochemistry", Ed: M.W. Chase and C.A. Williams, Academis Press, Inc., New York, 1968, pages 149-154).

Phenyl-Sepharose-CL4B is a derivative of Sepharose CL-4B; the latter is prepared by crosslinking the agarose with 2,3-dibromopropanol (patented, UK Patent I 352 613 and corresponding patents in other countries) and desulphating the resulting gel by alkaline hydrolysis under reducing conditions (J. Porath, Janson, J-C, Laas, T., "Agar derivatives for chromatography, electrophoresis and gel-bound enzymes. I. Desulphated and reduced crosslinked agar and agarose in spherical bead form". J. Chromatogr., 1971, 60: 167-177). The phenyl groups are introduced by reaction of Sepharose CL-4B with the glycidyl ether (S. Hjerten, Rosengren, J., and Pahlman, S., "Hydrophobic interaction chromatography. The synthesis and the use of some alkyl and aryl derivatives of agarose." Chromatogr., 1974, 101, 281-288) to produce a derivative with the phenyl group attached to the monosaccharide unit of the agarose matrix via ether linkage. The concentration of coupled phenol ligand is approximately 40 µmoles/ml swollen gel.

The EI active fraction of the Thiol-eluate was applied at approximately 22°C to a 3.5 cm column of Phenyl-Sepharose-CL4B (70 ml; Pharmacia) equilibrated against 10 mM Tris-HCl buffer, pH 7.4, 150 mM NaCl, 1 mM mercaptoethanol (Tris/150-NaCl/ME). Phenyl-Sepharose-CL4B separates proteins based on differences in their hydrophobicity. The nonadherent

fraction was collected, together with a with a 20 ml (approximately) wash using Tris/150-NaCl/ME. The presence of Human EI in the nonadherent fraction was confirmed as set forth above (FIG. 1).

Matrex gel Red A separation. Matrex gel Red A is a "group selective" affinity resin marketed by Amicon Corp., Lexington, MA. It consists of crosslinked 5% agarose with 3-5 mg of covalently coupled dye per ml swollen gel. The dye is known as red A, reactive red 120 and Procion Red HE3B, a registered trademark of Imperial Chemical Industries (Baird, J., Sherwood, R., Carr, R. and Atkinson, A., "Enzyme Purification by Substrate Elution Chromatography from Procion Dye-Polysaccharide Matrices.", FEBS Lett., 70: 61).

The Phenyl- nonadherent fraction (approximately 110 ml) was diluted with 0.5 volume Tris/ME and applied at 4°C to a 2 cm diameter column of 20 ml Matrex gel Red A equilibrated against Tris/100-NaCl/ME. Matrex gel Red A separates proteins based on their ability to bind to the Red A dye. The nonadherent fraction, including one column volume wash with Tris/100-NaCl/ME, was collected, tested for the presence of Human EI (FIG. 1), dialyzed against Tris/50-NaCl/ME for 3 hr at 4°C, and stored at -70°C.

HPLC DEAE-5PW Separation. DEAE-5PW is a weak anion exchange resin for high performance liquid chromatography (HPLC) that separates proteins based on small differences in charge properties. DEAE-5PW is prepared by introducing diethylaminoethyl (DEAE) groups onto a hydrophilic rigid resin; it is a product of Waters Division, Millipore Corp., Milford, MA), and is also known as Protein-Pak DEAE-5PW; (Protein-Pak is a tradename for various Waters resins). There is 0.1 micromole of effective DEAE groups per ml of resin. DEAE-5PW is a 10 micron spherical diethylaminoethyl functionalized polymethacrylate resin having 1000 angstrom pores. The resin is encased in a 7.5 x 75 mm 316 stainless steel column.

Portions (50 ml) of the dialyzed Red A-nonadherent fraction were filtered through 0.2 µm nylon membranes (Schleicher and Schuell, Keene, NH) and applied at 0.8 ml/min to the DEAE-5PW column equilibrated against Tris/50-NaCl/ME at 22°C. The column was washed with equilibration buffer. To elute Human EI, Tris/85-NaCl/ME was applied, and fractions absorbing at 280 nm were collected and assayed for the presence of Human EI as set forth above.

To concentrate EI, active fractions from 3-4 DEAE-fractionations were pooled, diluted with Tris/ME, and reapplied to the DEAE-5PW column in

Tris/50-NaCl/ME. A single EI-containing fraction of 1 to 2.5 ml was eluted with Tris/140-NaCl/ME. The presence of Human EI was confirmed as above. This fraction is 85-95% pure Human EI as indicated by gold-stained SDS electrophoresis gels, and since it is active and concentrated (e.g., 0.4 mg/ml), this preparation of Human EI is preferred for activity studies and functional studies.

HPLC-Gel Filtration Chromatography. For some applications, the remaining contaminants were removed by HPLC gel filtration chromatography using the HPLC gel filtration resin Protein-Pak I-125. Protein-Pak I-125, a product of Waters Division, is a 10 micron diol-bonded silica gel with a 100 Angstrom pore size. It consists of irregular silica particles covalently bonded with a dihydroxyalkyl silane to generate a hydrophilic material that is non-absorptive toward proteins and suitable for gel filtration chromatography. It is supplied encased in 7.8 x 30 mm columns of 316 stainless steel.

Portions of pooled concentrated Human EI from DEAE-5PW (200-1000 µl) were gel-filtered at 1.0 ml/min on two Protein-Pak I-125 columns in series totaling 7.8 x 600 mm equilibrated against 10 mM Tris HCl buffer, pH 7.4, 90 mM NaCl. Fractions absorbing at 214 nm (two peaks) were collected, and, after addition of mercaptoethanol to 1 mM, were assayed for content of Human EI as set forth above. The pooled

active peak (second peak) represents pure or substantially pure Human EI. Alternatively, the HPLC gel filtration was carried out using 50 mM NH_4HCO_3 as the buffer and the buffer was removed by lyophilization from the pooled fraction containing Human EI.

Fractions from the purification were analyzed by Laemmli SDS-electrophoresis as described (8). The polypeptides were gold stained after transfer to PVDF membranes (polyvinylidine difluoride; 0.45 μm; Millipore Corp., Bedford, MA) (constant 70 mAmps; 160v/1.6A power supply; Bio-Rad Laboratories, Richmond, CA) with 42 mM Tris/190 mM glycine buffer, pH 8.3 for 18 hr at ~22°C (Transphor Cell; Hoefer Scientific, San Francisco, CA). The PVDF membranes were washed seven times with 0.1% Tween-20 (Tween 20 is a registered trademark of ICI Americas for a polyethoxyethanol sorbitan; the product was obtained as a 10% aqueous solution packed in glass ampules under nitrogen from Pierce Co., Rockford, IL under the name Surfact-Amp 20) in PBS (2 x 15 min; 5 x 5 min) and twice with water, and were incubated with 0.2-0.3 ml/cm^2 of AuroDye protein stain (Janssen Pharmaceutica, Piscataway, NJ) at ~22°C for $\geq$ 4 hr. AuroDye is a stabilized colloidal gold sol (20 nm) adjusted to approximately pH 3 which stains proteins dark red.

Determination of molecular weight of EI. The apparent molecular weight of Human EI was determined as 42,000 by comparing its mobility on SDS electrophoresis gels (11) with that of previously described (8) pure proteins of known molecular weight; the proteins were detected by gold staining of electrophoretic transfers.

Inhibition of Elastinolysis. Human EI was assayed for elastinolytic activity by generation of a lytic zone in an elastin-containing agar gel (12). Generally, varying amounts of Human EI (pooled, concentrated DEAE fraction) were combined with either 75 ng or 150 ng pancreatic elastase for five minutes at about 22° C, and then were incubated in wells of fluorescein-elastin-agar plates for 48 hours at 37° C. The extent of elastinolysis, measured as the diameter of the lysis rings (average of duplicate determinations), was converted to units (one unit equaling the activity of one ng elastase) by reference to a parallel standard curve. Tests were run using 75 ng of elastase (boxes) and 150 ng of elastase (circles). Human EI caused dose-dependent inhibition of elastinolysis by elastase, thereby demonstrating that Human EI inhibits elastase (FIG. 2).

To demonstrate that the M_r 42,000 polypeptide is the elastase inhibitor, the DEAE-purified fraction was incubated with nonlabeled elastase and examined

on silver-stained (13) SDS-electrophoresis gels. The SDS gel included three lanes, one for EI, one for elastase and one for a mixture of the EI and elastase. On co-incubation for 1 min, the M_r 42,000 polypeptide and elastase disappeared concomitant with the formation of a M_r 66,000 elastase-elastase inhibitor complex (FIG. 3). This finding demonstrates that the M_r 42,000 polypeptide is the elastase inhibitor. It also shows that the bulk of the purified molecules have retained complex-forming activity and that the reaction of the purified molecule with elastase is rapid (complete at 1 min). The molecular weights of the reactants and the complex clearly suggest that the reaction has 1:1 stoichiometry.

Amino Acid Composition. An aliquot of lyophilized pure Human EI was hydrolyzed in 6 N HCl at 110°C for 24 hours and the amino acid composition was determined on a Dionex D-500 Analyzer. The content of Cys/2 (cysteine plus 1/2 cystine) was determined as cysteic acid after performic acid oxidation (14). The amino acid composition of the sample is presented in FIG. 4, together with the mean composition of 200 purified proteins and that of α1-AT, the known elastase inhibitor found in plasma.

Carbohydrate composition. The carbohydrate content of pure Human EI was determined by

methanolysis of a lyophilized sample by gas-liquid chromatography after conversion to the per(trimethylsilyl) derivatives (15). Per molecule of EI, 3.6 residues of xylose (believed to be a contaminant) and 0.5 residue of mannose (average values for two preparations) were detected. Galactose, N-acetylglucosamine, N-acetylgalactosamine, and sialic acid were not detected. Pure Human EI also was treated with the glycosidase PNGase F, which cleaves all classes of N-linked carbohydrate units (16). On treatment with 140-4200 mU/ml PNGase F, no change was detected in the apparent molecular weight of EI. The foregoing indicates that pure Human EI is a non-glycosylated protein or substantially non-glycosylated.

Amino Acid Sequencing. Two attempts to determine amino terminal sequence of pure Human EI yielded no sequence, suggesting that the amino-terminus is blocked. Therefore, it was decided to cleave the protein in order to determine amino acid sequence. Two preparations of Human EI, 40 µg and 76 µg, respectively, were examined, and treatment with the proteinase trypsin was the cleavage method chosen. Because of the possibility that Human EI would inhibit trypsin, the former was heat-treated (85-90°C for 8 min) to destroy its inhibitory activity. The heat-treated protein was incubated

with 0.003 parts trypsin at pH 8.0 at 37°C for 18 hr, conditions that were established in small-scale preliminary experiments. A small portion of the trypsin-treated preparation was analyzed by SDS-electrophoresis and gold-staining to insure that degradation of Human EI was complete.

The resulting tryptic peptides were fractionated by chromatography on a C_{18} reverse phase HPLC column with a 2-75% acetonitrile gradient in 0.1% trifluoroacetic acid in water. The C_{18} column is a 300 Angstrom pore size silica with a bonded phase with 5 micron particle size encased in a stainless steel column of .46 x 25 cm, from the Vydac Division, The Separations Groups, Hesperia, CA; it is intended for reverse phase HPLC chromatography of proteins and peptides. Fractions containing the separated peptide peaks were collected based on absorption at 214 nm; and solvent was removed by lyophilization. The peptide peaks were subjected to amino terminal amino acid sequencing on a gas phase protein sequencer (ABI 470A, Applied Biosystems, Foster City, CA) equipped with an on-line phenylthiohydantoin HPLC analyzer (ABI 120A On-line PTH analyzer).

Existence of Disulfide Bonds. 200 mM of mercaptoethanol does not adversely affect the ability of pure Human EI to form a complex with elastase. EI therefore does not appear to contain disulfide bonds, and in particular does not contain disulfide bonds that are essential for activity.

Essential Cysteine Residue. Addition of the sulfhydryl iodoacetamide (3mM) to pure Human EI causes almost complete loss of covalent complex activity with elastase. Destruction of unreacted iodoacetamide by addition of mercaptoethanol or removal by dialysis does not restore activity to pure Human EI. EI therefore appears to have a cysteine residue that is essential for the formation of the covalent elastase-EI complex.

Demonstration of EI in Monocytes, Macrophages and Neutrophils. Human EI was detected using the ^{125}I-elastase complex assay in lysates of human monocytes matured in culture and in the monocyte-like cell line U937-EI, but was not detected in freshly isolated human monocytes or neutrophils. When these latter cells were incubated with the active site reagent diisopropyl fluorophosphate (DFP) and lysed in the presence of DFP, and excess DFP removed from lysates by dialysis, Human EI activity was readily detected in fresh monocytes as well neutrophils (FIG. 5). Human EI activity was also detected in lysates of pulmonary macrophages obtained by broncholavage of healthy nonsmoker volunteers.

Cloning Human EI. Total mRNA is isolated from U937-EI cells and is "back translated" to cDNA using conventional procedures. Next, each of the cDNA molecules is inserted into a vector, such as for

example into the phage λgt11, thereby generating a cDNA library. Alternatively, a human monocyte or monocyte-like cDNA library in a vector such as λgt11 may be purchased.

The cDNA library is expressed in E. coli and grown up to ~10^5 E. coli colonies, each colony derived from one infected bacterium. The colonies then are screened to identify those colonies containing the λgt11 phage including the monocyte cDNA of interest. The detection probe for screening the E. coli colonies may be either an oligonucleotide encoding a portion of Human EI, or an antibody or antibodies to Human EI. Appropriate oligonucleotide probes are prepared synthetically, according to conventional techniques, based upon the Human EI sequencing data presented above. Appropriate screening antibodies are prepared by conventional immunization techniques using purified Human EI as the immunogen. Alternatively, peptides are synthesized by conventional procedures using sequences of EI peptides and used as immunogens to generate anti-Human EI antibodies. When the colony of interest is identified, the cDNA from the expression vector in that colony is isolated and the genomic complement to the cDNA for Human EI is isolated, all according to conventional techniques.

It will be understood by those skilled in the art that there are many equivalents to the foregoing

description of the preferred embodiment. For example, while the invention provides, among other things, a method for obtaining a cDNA copy of the mRNA for Human EI and the expression of that cDNA, various modifications of the cDNA and the expressed product are contemplated as within the scope of the invention. For example, cDNA sequences encoding Human EI may be changed at one or more base-pair positions or portions of the cDNA may be deleted while still retaining the ability of the expressed protein to act as an inhibitor of elastase or of other serine proteinases. The expressed protein therefore may include amino acid substitutions or deletions yet still be the functional equivalent of naturally occuring Human EI. Thus, genetically engineered Human EI, includes naturally occuring Human EI and variations, derivatives or portions thereof that maintain their ability to complex with and/or inhibit the activity of elastase. In this regard it will be understood by those skilled in the art that a molecule may inhibit the activity of elastase without forming a covalent complex with elastase. Thus very small portions of Human EI, and preferably those having the sequence of the elastase binding region of Human EI can have sufficient affinity for elastase so as to bind to and inhibit elastase, but not form a covalent complex with elastase. Such small portions or derivatives thereof

are contemplated as within the scope of the invention. These portions or derivatives may be prepared by conventional peptide synthesis or recombinant techniques.

The invention also contemplates portions and variations of Human EI coupled with moieties capable of reacting with the active site of a serine proteinase. In this instance, the portion or variation would recognize the serine proteinase and deliver the active moiety for inhibitory interaction with the serine active site.

Portions of Human EI also may be used as inhibitors of Human EI. For example, portions of Human EI that interact with elastase but that do not interfere with the activity of elastase, may be used to block in vivo the inhibitory action of Human EI by preventing the Human EI-elastase complex from forming. Thus, it will be understood by those skilled in the art that the products of the invention include portions of Human EI not capable of forming a covalent complex with elastase and oligonucleotides encoding such portions.

It also will be understood by those skilled in the art that there may be multiple related, but slightly different forms of naturally-occurring Human EI. Therefore, it further will be understood that there may be more than one mRNA sequence and more than one corresponding cDNA sequence encoding for

naturally-occurring Human EI. However, each such DNA sequence may be isolated according to the procedures set forth above and each form of Human EI may be obtained by expression vectors carrying each such cDNA sequence. Likewise, the genomic DNA corresponding to the various forms of Human EI then may be isolated in a conventional manner.

The naturally occuring Human EI and variations, derivatives and portions thereof may be used in pharmaceutically effective amounts to treat medical conditions. Generally, they may be used for treatment of conditions involving destructive action by elastase and by other proteinases with which they react, including tissue destruction as a consequence of inflammation. Specific applications include bronchiectasis as a consequence of inflammation in the lung, intestinal tissue damage in chronic granulatomous disease and LAD (leukocyte adhesion deficiency), cystic fibrosis, pancreatitis, malignancies, blood damage vessel due to clotting, blistering skin disorders, reperfusion injury, and ulcerative colitis. Other applications include all conditions where Human EI level is abnormal, elastase or other proteinases reactive with Human EI are in excess, or when there is phagocyte accumulation in excess.

The naturally-occurring Human EI and variations, derivatives and portions thereof also may be employed

to create antisera for the detection of the presence or absence or the quantity of Human EI, useful in evaluating congenital or acquired deficiencies and also in evaluating disease states. For example, antibodies to Human EI may be used to evaluate the level of phagocytic cell response in infectious disease states such as tuberculosis and leprosy. Likewise, such antibodies may be used to diagnose inflammatory states such as rheumatological diseases (e. g., rheumatoid arthritis), immunological diseases (e.g., pemphigus), idiopathic diseases (e.g., sarcoidosis) and inflammatory diseases (e.g., adult respiratory distress syndrome.) Antibodies further may be used as a diagnostic tool in connection with neoplastic diseases (e.g., monitoring of malignancies by evaluation of host response, evaluating the metastatic capacity of malignant cells), in genetic diseases (e.g., cystic fibrosis or hereditary abnormalities in the elastase-elastase inhibitor system), in abnormal maturation of myelomonocytic cells (e.g., Chediak-Higashi syndrome), in pancreatitis and other disorders of the pancreas, and generally for evaluation of the genetic variability of the elastase-elastase inhibitor system in the population and its relationship to diseases.

Antibodies to Human EI also have therapeutic uses, including treatment of conditions in which elastase is abnormal, elastase inhibitor is in excess

over elastase, or phagocyte recruitment is defective. Such conditions include abnormality and susceptibility to infections or inadequate immune defense.

Likewise, oligonucleotides complementary to ribonucleotides encoding Human EI or a portion thereof may be useful for some of the above-noted diagnostic purposes. Further, the oligonucleotides encoding Human EI or a portion, derivative or variation thereof, alone or as part of a suitable expression vector or delivery system may be useful in gene replacement therapy relating to the conditions described above. Preparations containing effective amounts of such oligonucleotides, suitable expression vectors or delivery systems are made using conventional cloning and isolation techniques as described above or by other methods such as PCR (polymerase chain reaction). These and many other uses will be apparent to one of ordinary skill in the art.

The foregoing description is intended to be taken in an illustrative, and not a limiting, sense.

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Claims

Claim 1. A substantially pure preparation of a single polypeptide molecule having a molecular weight of about 42,000 and a structure that is substantially non-glycosylated and that is capable of:

forming a covalent complex with elastase; and

acting as an inhibitor of the elastinolytic activity of elastase.

Claim 2. A substantially pure preparation as claimed in claim 1 further characterized in that treatment of said molecule with iodoacetamide is capable of preventing the molecule from forming a complex with pancreatic elastase and in that said molecule has no essential disulfide bonds.

Claim 3. A substantially pure preparation of Human EI, or of a variation, portion or derivative thereof.

Claim 4. A preparation containing a therapeutically-effective amount of Human EI, or a variation, portion or derivative thereof.

Claim 5. A preparation as claimed in claim 4 further comprising a moiety capable of reacting with the active site of a proteinase coupled to a portion, derivative or variation of Human EI.

Claim 6. a preparation as claimed in claim 4 wherein said Human EI, variation, portion or derivative thereof. includes the protein sequence selected from the group of sequences consisting of:

(1) Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

(2) Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

(3) Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

(4) Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

(5) Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

(6) Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

(7) Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

(8) Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

(9) Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

(10) Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

Claim 7. A recombinant vector containing a DNA sequence encoding a molecule selected from the group consisting of:

(1) Human EI;

(2) derivatives, variations or portions of Human EI;

(3) a molecule including the protein sequence of Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

(4) a molecule including the protein sequence of Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

(5) a molecule including the protein sequence of Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

(6) a molecule including the protein sequence of Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

(7) a molecule including the protein sequence of Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

(8) a molecule including the protein sequence of Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

(9) a molecule including the protein sequence of Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

(10) a molecule including the protein sequence of Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

(11) a molecule including the protein sequence of Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

(12) a molecule including the protein sequence of Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

Claim 8. A recombinant vector as claimed in claim 7 wherein the molecule is capable of acting as an inhibitor of a serine proteinase.

Claim 9. A recombinant vector as claimed in claim 7 wherein the molecule is capable of acting as an inhibitor of elastase.

Claim 10. A recombinant vector as claimed in claim 7 wherein said molecule is capable of forming a covalent complex with elastase and capable of acting as an inhibitor of elastase.

Claim 11. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding Human EI.

Claim 12. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a derivative, variation or portion of Human EI.

Claim 13. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of Leu-Gly-Val-Gln- Asp-Leu-Phe-Asn-Ser.

Claim 14. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys.

Claim 15. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of a molecule including the protein sequence Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys.

Claim 16. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys.

Claim 17. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg.

Claim 18. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser.

Claim 19. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence encoding a molecule including the protein sequence of Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala.

Claim 20. A non-naturally occurring molecule capable of acting as an inhibitor of a serine proteinase and including at least a portion of Human EI.

Claim 21. A non-naturally occurring molecule as claimed in claim 20 wherein said molecule is capable of acting as an inhibitor of elastase.

Claim 22. A non-naturally occurring molecule as claimed in claim 21 further characterized in that said molecule is capable of forming a covalent complex with elastase and wherein treatment with iodoacetamide abrogates the molecule's ability to form a complex with elastase.

Claim 23. A non-naturally occurring molecule as claimed in claim 21 further characterized by an amino acid sequence selected from the group consisting of:

(1) Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

(2) Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

(3) Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

(4) Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

(5) Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

(6) Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

(7) Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

(8) Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

(9) Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

(10) Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

Claim 24. A method for isolating the gene for Human EI comprising using detection probe containing an oligonucleotide sequence encoding at least a portion of Human EI.

Claim 25. A substantially pure preparation of an oligonucleotide encoding Human EI or a variation, derivative or portion thereof.

Claim 26. A substantially pure preparation as claimed in claim 25 wherein said oligonucleotide encodes a protein including an amino acid sequence selected from the group consisting of:

(1) Leu-Gly-Val-Gln-Asp-Leu-Phe-Asn-Ser;

(2) Phe-Ala-Tyr-Gly-Tyr-Ile-Glu-Asp-Leu-Lys;

(3) Tyr-Asn-Phe-Leu-Pro-Glu-Phe-Leu-Val-Ser-Thr-Gln-Lys;

(4) Leu-Asp-Asn-Val-Gly-His-Leu-Pro-Ala-Gly-Gly-Ala-Val-Lys;

(5) Glu-Ala-Thr-Thr-Asn-Ala-Pro-Phe-Arg;

(6) Phe-His-Phe-Asn-Thr-Val-Glu-Glu-Val-His-Ser;

(7) Tyr-Gly-Ala-Asp-Leu-Ala-Ser-Val-Asp-Phe-Gln-His-Ala-Ser-Glu-Asp-Ala;

(8) Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro;

(9) Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys; and

(10) Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

Claim 27. A preparation containing a diagnostic amount of an antibody with selective specificity for Human EI.

Claim 28. A substantially pure preparation of an antibody capable of binding to Human EI.

Claim 29. A method for treating a medical condition comprising administering to a patient a pharmaceutically effective amount of a preparation containing Human EI or variations, portions or derrivatives thereof.

Claim 30. A method for treating a medical condition comprising administering to a patient a

pharmaceutically effective amount of a preparation containing antibodies to Human EI.

Claim 31. A method for treating a medical condition comprising administering to a patient an oligonucleotide containing a DNA sequence encoding Human EI or a variation, portion or derivative thereof.

Claim 32. A method for diagnosing a medical condition comprising using a diagnostically effective amount of Human EI or variations, portions or derivatives thereof.

Claim 33. A method for diagnosing a medical condition comprising using a diagnostically effective amount of antibodies to Human EI.

Claim 34. A method for diagnosing a medical condition comprising using a diagnostically effective amount of oligonucleotides encoding Human EI.

Claim 35. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence in coding a molecule including the protein sequence of Val-Leu-Glu-Leu-Pro-Tyr-Gln-Gly-Glu-Glu-Leu-Ser-Met-Val-Iso-Leu-Leu-Pro.

Claim 36. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence in coding a molecule including the protein sequence of Lys-Ile-Glu-Glu-Gln-Leu-Thr-Leu-Glu-Lys.

Claim 37. A recombinant vector as claimed in claim 7 wherein said vector contains a DNA sequence in coding a molecule including the protein sequence of Phe-Lys-Leu-Glu-Glu-Ser-Tyr-Thr-Leu-Asn-Ser-Asp-Leu-Ala-Arg.

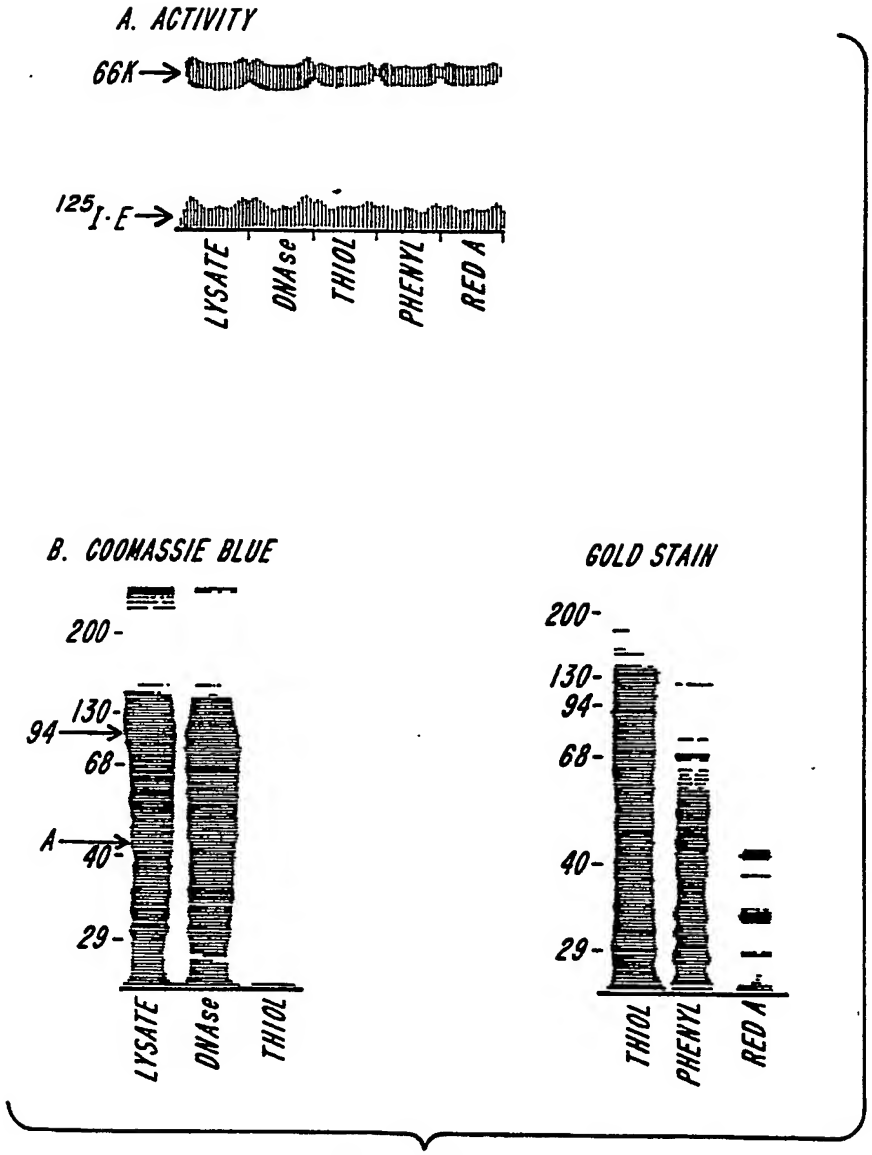
A. ACTIVITY
66K
125I-E
LYSATE
DNAse
THIOL
PHENYL
RED A
B. COOMASSIE BLUE
GOLD STAIN
200-
130-
94-
68-
A
40-
29-
LYSATE
DNAse
THIOL
THIOL
PHENYL
RED A

FIG. 1

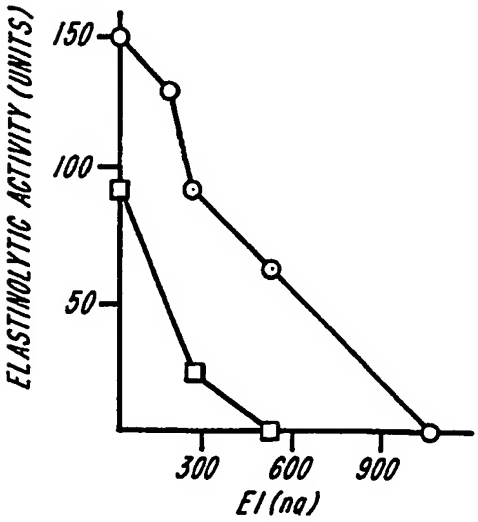
ELASTINOLYTIC ACTIVITY (UNITS)
150
100
50
300
600
900
EI (ng)

FIG. 2

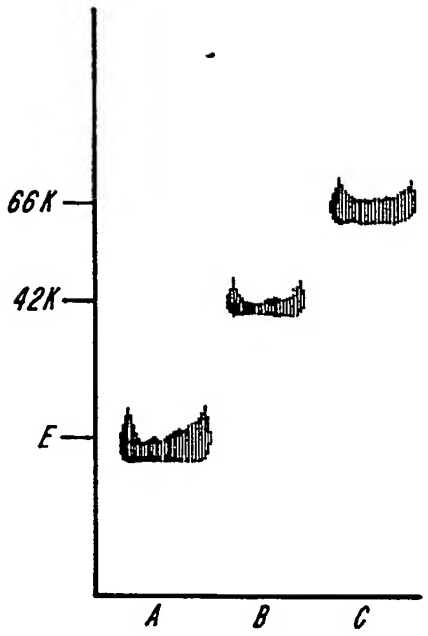
66K
42K
E
A
B
C

FIG. 3

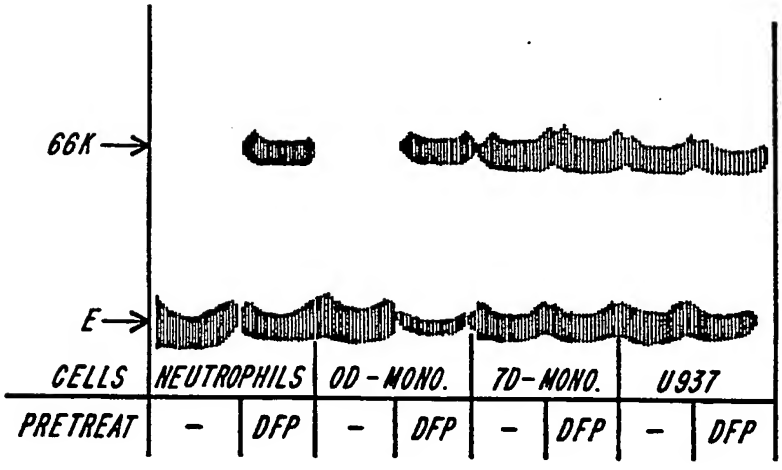
66K
E
CELLS
NEUTROPHILS
0D-MONO.
7D-MONO.
U937
PRETREAT
-
DFP
-
DFP
-
DFP
-
DFP

FIG. 5

AMINO ACID COMPOSITIONS

	No. Residues/100 Amino Acids			No. of Residues/Molecule	
Residue	Avg. of 200 proteins*	EI$	α1-AT#	EI$	α1-AT#
Asx	10.7	11.1	10.9	40	43
Glx	10.6	12.3	12.4	44	50
His	2.2	1.9	3.5	7	13
Lys	6.5	7.1	8.6	26	34
Arg	4.4	3.8	1.8	14	7
Ser	6.3	8.1	5.3	29	21
Thr	5.7	5.7	7.6	21	30
Pro	4.8	5.4	4.3	20	17
Ala	8.5	8.1	6.1	29	24
Cys	2.3	1.5	0.2	5	1
Gly	8.1	7.0	5.6	25	22
Tyr	3.3	2.1	1.5	8	6
Val	6.8	5.2	6.1	19	24
Ile	5.0	3.0	4.8	11	19
Leu	8.1	9.2	11.4	33	45
Phe	3.7	4.9	6.8	18	27
Met	1.9	2.0	2.3	7	9
Trp	1.3	ND	0.5	ND	2
Total				~360	394

*The mean amino acid composition of >200 proteins is from Reeck, G.R., Fisher, L. "A Statistical Analysis of the Amino Acid Compositions of Proteins." Int. J. Peptide Protein Res., 1973, 5:109-117.
$EI values are means of data from three preparations. No. of residues per molecule EI were calculated based on Mr=42,000.
#α-1AT composition is calculated from Carrell, R.W., Jeppsson, J-O., Laurell, C-B., Brennan, S.O., Owen, M.C., Vaughan, L., Boswell, D.R., "Structure and Variation of Human α1-Antitrypsin." Nature, 1982, 298:329-334.
N.D. = not determined.

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/00920

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): A01N 37/18; A61K 37/00,37/02; C07H 15/12, 17/00; C07K 3/00, 5/00,7/00,13/00,15/00, 17/00; C12N 15/00; C12Q 1/00,1/68; G01N 33/53 US CL: 435/6,7,320; 514/2; 530/300,350,536/27

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	435/6,7,320; 514/2 530/300,350 536/27

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

A.P.S., DIALOG Databases. AA Sequence Search Spt,pir databases

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
P,X P,Y	Journal of Experimental Medicine, Volume 169, pages 1071-1086. March 1989. REMOLD-O'DONNELL ET AL. "Elastase Inhibitor Characterization of the Human Elastase Inhibitor Molecule Associated with Monocytes, Macrophages, and Neutrophils". See page 1082, Summary.	1-6 1-37
X Y	Journal of Experimental Medicine, Volume 162, pages 2142-2155. December 1985. E. REMOLD-O'DONNELL ET AL. "A fast-ACTING ELASTASE Inhibitor in Human Monocytes". See entire document.	1-6 1-37
A	Journal of Clinical Investigation, Volume 69(2), pages 384-393. February 1982. R.M. SENIOR ET AL. "Elastase of U-937 Monocyte-like Cells. Comparisons with elastases derived from human monocytes and neutrophils and murine macrophagelike Cells.	1-37
Y	Journal of Clinical Investigation, Volume 77(5), pages 1675-1681. 1986. H.G. WELGUS, ET AL. "12-O Tetradecanolyphorbol-13-acetate-differentiated U-937 cells express a macrophage-like profile of neutral proteinases high levels of secreted	1-37

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
13 MAY 1990	16 JUL 1990
International Searching Authority [1]	**Signature of Authorized Officer** [20]
ISA/US	THOMAS M. CUNNINGHAM

Form PCT/ISA/210 (second sheet) (May 1986)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

	collagenase inhibitor accompany low levels of intracellular elastase and cathepsin G". See abstract.	
A	Proceedings of the National Academy of Sciences, USA, Volume 84, pages 2228-2232. S.SINHA ET AL. April 1987. "Primary Structure of Human Neutrophil Elastase".	1-37
A	Journal of Biological Chemistry, Volume 263(5), pages 2543-2547. H. TAKAHASHI, ET AL. February 1988. "Myelomonocytic Cell Lineage Expression of Neutrophil Elastase Gene".	1-37

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers . ... , because they relate to subject matter [1] not required to be searched by this Authority, namely:

2. ☐ Claim numbers..... , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [1], specifically:

3. ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.